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ABSTRACT

A study examined whether computers equipped with speech synthesis devices could facilitate children's writing. It was hypothesized that children using the devices would write longer stories, edit more, and produce higher quality stories than children not receiving feedback from a speech synthesizer. Subjects were 48 children, three girls and three boys each drawn from two second grade and two fifth grade classrooms in two different schools. Subjects from one second grade and one fifth grade classroom at each school wrote one story under the spoken feedback condition and then two stories under the nonspoken condition. Experimental conditions were reversed for the other two classrooms. Results showed that using a speech synthesizer led to increased levels of editing in young children. In addition, preference for the spoken feedback was negatively related to story length for both second and fifth grade students, to audience awareness for second grade students, and to story level editing for fifth grade students, indicating that less-skilled writers were the most motivated by hearing spoken feedback. References, tables and figures are appended. (FL)

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The Effects on Children's Writing of Adding Speech Synthesis to a Word Processor

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THE EFFECTS ON CHILDREN'S WRITING OF ADDING SPEECH SYNTHESIS TO A WORD PROCESSOR

Introduction

The computer as a writing tool may facilitate the development of writing skills. Children who are not yet capable of writing by hand are able to learn how to use a keyboard to write (Collins, 1984; Daiute, 1985; Kleiman & Humphrey, 1982; Schwartz, 1982). Those who are reluctant to write with a pencil seem to enjoy writing with a word processor (Chandler, 1984; Kleiman & Humphrey, 1982). Young writers tend to produce longer and higher quality compositions when using a computer instead of pencil and paper (Collins, 1984; Levin, Boruta, & Vasconcellos, 1983). Moreover, writers of all ages report deriving satisfaction from being able to edit easily and produce clean, printed copies of their writing (Chandler, 1984; Kleiman & Humphrey, 1982; MacArthur & Shneiderman, 1984; Newman, 1983; Schwartz, 1982). For these reasons, access to a word processor may motivate writers of varying levels of experience and ability (Collins, 1984; Daiute, 1982; Hennings, 1981; Marcus, 1984; Warash, 1984).

The recent advances in technology that have made it possible to add spoken feedback to word processors may further facilitate the writing process for several reasons. First, because aspects of spoken and written language are intertwined for young, beginning writers (Kroll, 1981), providing spoken language as a support during the writing process may enable children "to take

risks and interact with written language with a sense of competence" (Rosegrant, 1984, p. 58). Second, as they mature and learn to differentiate between spoken and written words, hearing the computer "speak" their written words may encourage children to take an audience's perspective on their work, which many consider an important component in the development of writing skills (Rubin, 1984). As Bruce, Collins, Rubin, & Gentner (1982) have noted, more editing and revising may result from understanding that "to write is to communicate" (Bruce et al., 1982, p. 131). Finally, writing with a "talking" computer may also prove motivational in both acquiring and using writing skills.

Two recent commercial programs, Writing to Read and Talking Screen Textwriter, both utilize synthesized speech in the attempt at facilitating the development of skills associated with reading and writing. In the Writing to Read program, a speech synthesizer is used to pronounce single phonemes and words for young children during preparatory activities for writing stories. Speech synthesis is not used during the actual writing process. The Talking Screen Textwriter program does use the synthesizer during the writing process. The writer can choose to have letters, words, sentences, or longer sections of text spoken aloud. This program has been used with children who "have been diagnosed as having a communication disorder or learning disability, or as educably or trainably retarded" (Rosegrant,

1984, p.57). An adult who assumed the role of a resource person was present during the entire session.

Both the Writing to Read and Talking Screen Textwriter approaches have been evaluated positively (Educational Testing Service, 1984; Casey, 1984.) However, it is not possible in either case to assess the role of synthesized speech independently of other factors, such as social interaction. To determine whether or not speech synthesis facilitates writing requires individual use of a computer equipped for speech synthesis.

Based upon the considerations outlined above, it was hypothesized that stories written under the spoken feedback condition would be longer, would be edited more, and would be of higher quality than those written without feedback from the speech synthesizer. Furthermore, it was predicted that spoken feedback would be related to writers' reports of increased motivation and audience awareness.

Method

A cross-over design was used. One group of students began the experiment using a word processor supplemented by a speech synthesizer. The second group began by using the same word processing program, but did not receive supplemental spoken feedback. After subjects wrote two stories, the experimental conditions were reversed for the two groups, and each child wrote two additional stories.

Subjects

A random sample of six children, three girls and three boys, was drawn from two second grade and two fifth grade classrooms at two public elementary schools, for a total of forty-eight subjects. Students with learning difficulties or limited English ability were not included. Second graders ranged in age from 7 years 8 months to 8 years 10 months, with a mean age of 8 years 1 month; fifth graders ranged in age from 10 years 3 months to 11 years 9 months, with a mean age of 10 years 11 months.

Design

Subjects from one second grade classroom and one fifth grade classroom at each school wrote two stories under the spoken feedback condition and then two stories under the non-spoken condition. Experimental conditions were reversed for the other two classrooms.

Four pictures showing children in intriguing situations were used as story stimuli. Four story orders were randomly assigned to experimental condition. Students were taken individually from their classrooms once a week for the four writing sessions. The experimenter explained how to use the word processing program during each subject's first session. At the beginning of each session, the experimenter presented the stimulus picture and read the instructions. Writing or editing suggestions were not offered or supplied, if requested by the child.

Subjects were interviewed by the experimenter before the groups switched experimental conditions and again upon completion

of their final story. The first interview included questions related to audience awareness; the second repeated these questions and added questions related to motivation, writing preferences, and computer experience.

Software

The word processing program used in this study activates a speech synthesizer (Votrax Personal Speech System) whenever a period, question mark, or exclamation point is entered from the keyboard, ending the current sentence. The sentence is "spoken," and then the writer may elect to hear it again, change it, or continue. Once spoken, editing a sentence requires retyping it. A decision to continue is coupled with options to hear the whole story, following which previous sentences may be edited, or to enter the next sentence. The program was essentially the same in the non-spoken condition except that the options to hear the sentence or story were eliminated. In general, children quickly learned how to use the program and only occasionally asked questions regarding various options.

Dependent Measures

Five dependent variables--length, editing, quality, motivation, and audience awareness--were measured. Length was defined in three ways: the total number of keystrokes entered, the number of keystrokes in the final version of the story, and the number of sentences in the completed story. Editing was coded from keystroke data, and changes in re-entered sentences were also analyzed. The quality of each story was judged

holistically, based on the Primary Trait System (PTS) (Klaus, Lloyd-Jones, Brown, Littlefair, Mullis, Miller, & Verity, 1979) approach to writing assessment and upon a Q-sort ranking of the stories by grade for each stimulus picture that was developed for this study. Motivation and audience awareness were coded from interview responses. Details of the coding procedures for these dependent measures are given elsewhere (Borgh, 1985).

Results

A mixed model repeated measures analysis of variance was conducted on each of the following dependent measures individually: length, editing, and quality of story. The BMDP2V statistical program (Dixon, 1982) was used for these analyses. The between-Ss portion of the design consisted of four two-level variables: Grade (2 versus 5), School (1 versus 2), Sex (male versus female), and Feedback Condition (spoken versus non-spoken). The within-Ss portion of the design consisted of stories (1 versus 2) nested within phase (before crossover versus after crossover). For audience awareness measures the within-Ss portion of the design consisted of phase (before crossover versus after crossover). For motivation there was no within-Ss component to the design.

Length Measures

It was predicted that children would write more when receiving spoken feedback. Three measures of length were analyzed: total keystrokes (KEYSTROKES TOTAL), keystrokes in the final story (KEYSTROKES FINAL), and number of sentences

(SENTENCES). Although the means for all of the length measures tended to be higher for stories written under the spoken feedback condition, none of the differences related to length measures and feedback condition were statistically significant.

Editing Measures

It was predicted that children would do more editing when receiving spoken feedback than when receiving no spoken feedback. Editing occurred either before a period was entered or in response to options presented on the screen after a sentence was ended. The latter type of editing was analyzed in this study because it occurred subsequent to hearing the spoken feedback. According to the program format, this type of editing could take place just after entering a sentence, with the writer changing that particular line (SENTENCE), or after hearing or re-reading the whole story (STORY). With the latter option, the writer usually edited a sentence prior to the one just entered. Tables 1 and 2 summarize the descriptive statistics for these measures of editing, summed for the first two (before crossover) and last two (after crossover) stories.

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Insert Table 1 here

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The most general test of the hypothesis that spoken feedback will elicit more editing, is an analysis of variance in which SENTENCE and STORY level editing are treated as a two-level factor. In this combined analysis, a significant relationship

was found between feedback and editing, such that more editing was performed under the spoken feedback condition ($F_{1,32} = 14.6$, $p < .001$).

Because there was a significant interaction between feedback condition and the SENTENCE and STORY editing measures ($F_{1,32} = 27.0$, $p < .001$), further analyses of variance were performed on the two measures separately. Spoken feedback was found to be related to significantly more editing at the SENTENCE level ($F_{1,32} = 31.2$, $p < .01$), but not at the STORY level ($F_{1,32} = 1.2$, $p > .05$). These results are presented graphically in Figures 1 and 2. Writers did more editing at the SENTENCE level when receiving spoken feedback; though less striking, they also seemed to do slightly more editing at the STORY level when no spoken feedback was provided. (A possible, though not verifiable, interpretation of these results is that spoken feedback helped writers catch errors at the SENTENCE level, making STORY level editing less necessary in the spoken condition.)

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Insert Figures 1 and 2 here

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Although the mean number of changes shown in Tables 1 and 2 seem small in absolute numbers, they seem less so when compared with the average number of about six sentences per story for second graders and nine sentences per story for fifth graders. Furthermore, at the SENTENCE level, the number of editing acts

under the spoken feedback conditions ranges from approximately three to seven times greater than under the non-spoken feedback conditions.

Quality Measures

It was predicted that children would write higher quality stories under the spoken, than under the non-spoken, feedback condition. Two measures of story quality were used in data analysis, as determined by application of the PTS and Q-sort approaches to writing assessment. These measures were combined and entered into a repeated measures analysis of variance to test for significant effects of feedback condition on story quality. No statistically significant effects related to feedback condition or phase were found. Each quality measure was also analyzed separately, with similar results.

Motivation Measure

It was predicted that children would report being more motivated to write when receiving spoken feedback, as contrasted with receiving no such feedback. In the final interview 40 of 48 writers (83.3%) indicated that they enjoyed writing better when the computer "talked" than when it "didn't talk". Of the remaining eight, only two (4.2%) preferred using the non-spoken version of the program, with six writers (12.5%) indicating ambivalent feelings regarding use of the two versions. A Kolmogorev-Smirnov Goodness of Fit Test was performed in order to test whether this pattern of responses differed from a normal distribution. The results of this test were significant (K-S Z =

4.7, p = .000). (Kolmogorov-Smirnov tests were also performed by grade, with similar results: 2nd grade, K-S Z = 3.5, p = .000; 5th grade: K-S Z = 3.4, p = .000.)

Audience Awareness Measures

It was hypothesized that writers would report higher levels of audience awareness when writing with spoken feedback than without spoken feedback. Children were asked whether or not they thought about a specific audience (AUDIENCE) while writing and whether or not they changed anything with the needs of someone else in mind (CHANGES). AUDIENCE responses were coded according to a 0-2 scale; CHANGES responses were coded according to a 0-3 scale. These measures were combined and entered into a repeated measures analysis of variance. There were no significant effects of feedback condition on audience awareness, with similar results occurring when the measures were entered separately.

Other Results

In this section, statistically significant, unhypothesized relationships between various dependent measures and two independent variables, grade and sex, are discussed.

Grade Differences

Fifth graders wrote more than second graders (KEYSTROKES TOTAL: $F_{1,32} = 17.3$, $p < .001$; KEYSTROKES FINAL: $F_{1,32} = 20.4$, $p < .001$; SENTENCES: $F_{1,32} = 7.3$, $p < .05$). They also wrote stories of higher quality, using the PTS approach to evaluation ($F_{1,32} = 12.5$, $p < .01$). There were no statistically significant

differences related to grade level and any other dependent measures used in this study.

Sex Differences

Sex differences were found for length, editing, quality, and motivation measures. There were significant effects of sex on all of the length measures entered into the repeated measures analyses of variance (KEYSTROKES TOTAL: $F_{1,32} = 6.3$, $p < .05$; KEYSTROKES FINAL: $F_{1,32} = 6.6$, $p < .05$; SENTENCES: $F_{1,32} = 4.7$, $p < .05$), with girls tending to write longer stories than did boys. They also made more STORY level changes than did boys ($F_{1,32} = 4.9$, $p < .05$), and tended to write stories of higher quality (combined Q-sort and PTS: $F_{1,32} = 7.3$, $p < .05$; Q-sort only: $F_{1,32} = 8.0$, $p < .01$; PTS only: $F_{1,32} = 4.9$, $p < .05$). Boys reported preferring the spoken version of the program more often than did girls ($F_{1,32} = 5.3$, $p < .05$).

Post Hoc Analysis of Types of Editing

In view of the substantially increased level of editing observed in the spoken feedback condition, more detailed examination of the types of editing seemed appropriate. Changed sentences were identified and compared with their original versions, and seven categories of editing were coded: correction of typing errors, spelling, or punctuation; changes at the single word, multiple word or phrase, or sentence levels; and the insertions of new errors. Two summary measures were created to reflect "lower level" and "higher level" editing. The former represents the sum of typing error, spelling, and punctuation

corrections; the latter represents the sum of changes at the single word, multiple word or phrase, and whole sentence levels.

Of the 48 participants in this study, 17 second graders and 21 fifth graders edited one or more completed sentences (see previous discussion of editing measures). The number of changes per writer across the four stories of this study ranged from one to fourteen (mean = 3.6). Moreover, while 68.2% of the edited sentences included instances of "lower level" editing, 46.3% also included instances of "higher level" editing. (An edited sentence could include several types of editing; therefore, "lower level" and "higher level" percentages do not sum to 100%.)

In light of children's reluctance to edit and revise (Bradley, 1984; Liebling, 1984), the results of this study are especially encouraging. Regardless of grade level, school, or sex, children did between three and seven times more editing under the spoken feedback condition.

Relationships among Dependent Measures

In order to explore relationships among the dependent measures used in this study, selected correlations were computed. As indicated in Table 2, there was a strong relationship between length and quality measures, for both the second grade and fifth grade samples. The association between "writing more" and "writing better" (Collins, 1984; Levin et al., 1984) is supported by these results.

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Insert Table 2 about here

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Furthermore, children who indicated that they wrote with a specific audience in mind, tended to write longer stories, at both the second grade and fifth grade levels, and stories of higher quality, at the fifth grade level. These results are consistent with the view that audience awareness is a developing skill, and a key component to better writing.

Finally, preference for the spoken feedback condition was negatively related to story length for both second and fifth graders, to audience awareness for second graders, and to STORY level editing for fifth graders. The relationships among these measures indicate that less-skilled writers were those most motivated by hearing spoken feedback.

Discussion

This study may be viewed as contributing to the field of research concerned with utilizing multiple modalities to foster the development of communication skills. Dickson (1985) includes talking word processors in his discussion of using computer software to juxtapose symbol systems in ways which facilitate "metacognitive awareness, social awareness, and competence in culturally valued productive symbol systems" (Dickson, 1985, p. 30). Based on observations of fifth graders using a talking word processor, he suggests that juxtaposing "the more automatic, overlearned system for processing oral speech

with the written symbol system activated a greater depth of processing of the written text than otherwise might have occurred" (Dickson, 1985, p. 33). Capitalizing upon overlearned oral language in order to enable more competent performance in writing is consonant with Bereiter's (1979) assertion that "...under facilitating emotional and stimulus conditions children can sometimes perform in ways characteristic of older children and adults..." (Bereiter, 1979, p. 80), though here the facilitation is cognitive rather than motivational.

The increased levels of editing evidenced under the spoken condition in this study tend to support this position. Some of the writers in this study described their subjective reactions as follows: "...when the computer talks it sorta sounds like someone else is reading it to me and that way if it doesn't sound quite right like when the computer reads it to me, then I can change it and make it more amusing"; "It made me feel like um like somebody else could understand it so I felt more fluent in the ideas I got"; "...when you hear it it might be better, when you hear it than read it, 'cause sometimes hearing is better than seeing, and sometimes it's the other way around."

These remarks suggest that spoken feedback may have fostered an awareness of the need to edit. From reported preferences for writing with the "talking" computer, it may also be inferred that spoken feedback may have contributed to a willingness to edit. Although some participants did express a desire for more control over when spoken feedback was given, most writers responded

enthusiastically to hearing the speech synthesizer: "...it's more exciting to hear it being read"; "It made me feel happy that it was like he was a person and he could read what I wrote and he kinda understood it even though I know he really didn't."; "It's kinda dull using one that doesn't talk."

Additional research is needed to determine whether or not access to a speech synthesizer would prove motivating over time. Future efforts could include giving young writers access to a more powerful word processor, similar to Talking Screen Textwriter, which allows for easier editing and for more control over when spoken feedback is given.

The results of this study also suggest immediate practical applications of "talking" word processors in the classroom. Teachers could encourage young writers to listen for errors ("lower level" skill), as well as for content ("higher level" skill), providing for individual, pair, and small group writing experiences. This approach incorporates concerns related to competence in culturally valued symbol systems, metacognitive awareness, and social awareness (Dickson, 1985). (It is worth mentioning that speech synthesizers of the quality used in this study are available for about $200.)

Similarly, a speech synthesizer could also be used to facilitate children's experimentation with the varied roles of reader, writer, listener, and speaker. For example, if a child writes relying heavily on phonetic spellings, words may be heard correctly but be difficult to read; if a child writes the way he

or she speaks in describing a sequence of events, spoken feedback may aid the child in detecting important missing details. Research is needed to determine ways in which utilizing synthesized speech may contribute to the creation of a rich environment for the exploration of the relationships between reading, writing, listening, and speaking and the development of corresponding skills.

Conclusion

The results of this study indicate clearly that using a "talking" word processor can lead to increased levels of editng in young children. Furthermore, children report preferring the version of the word processor with spoken feedback. Finally, in view of the growing interest in the effects of using computers on writing, the present study suggests that further research on the use of word processors equipped with speech synthesis capabilities should be a high priority for both researchers and educators.

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Table 1
Descriptive Statistics for Editing Measures

Before Crossover

	SENTENCE		STORY	
	mean	std.dev.	mean	std.dev.
2nd Grade				
talking	1.4	1.9	.3	.7
not talking	.2	.4	.8	1.2
5th Grade				
talking	1.3	1.3	.6	.9
not talking	.4	1.0	1.0	1.2
Combined	.8	1.4	.7	1.0

After Crossover

	SENTENCE		STORY	
	mean	std.dev.	mean	std.dev.
2nd Grade				
not talking	.3	1.1	.6	.7
talking	1.1	1.1	.1	.3
5th Grade				
not talking	.3	.5	.2	.6
talking	1.9	1.9	.8	1.1
Combined	.9	1.4	.4	.8

Table 2

Correlations among Dependent Measures

	Q-SORT	PTS	Q+P	AUDI	MOTIV
KEYSTROKES TOTAL	.63*	.58*	.63*	.43	-.32
	.75*	.77*	.77*	.47*	-.42*
KEYSTROKES FINAL	.66*	.59*	.65*	.39*	-.34
	.76*	.79*	.79*	.45*	-.34
# OF SENTENCES	.72*	.70*	.73*	.00	-.05
	.44*	.46*	.46*	.01	-.21
EDITING: SENTENCE	.20	.15	.19	.15	.08
	.26	.21	.25	.00	.15
EDITING: STORY	.29	.35	.31	-.02	.02
	.35*	.35*	.36*	.22	-.45*
Q-SORT	-	.89*	.99*	.12	-.06
	-	.91*	.99*	.44*	-.32
PTS	-	-	.95*	.11	-.04
	-	-	.96*	.34	-.29
Q-SORT + PTS	-	-	-	.12	-.05
	-	-	-	.41*	-.31
AUDIENCE	-	-	-	-	-.52*
	-	-	-	-	-.09
MOTIVATION	-	-	-	-	-
	-	-	-	-	-

* $p < .05$

Note: Correlations for Grade 2 are in the first row, and correlations for Grade 5 are in the second row for each measure.

Figure 1: Sentence Level Editing:
Before and After Crossover

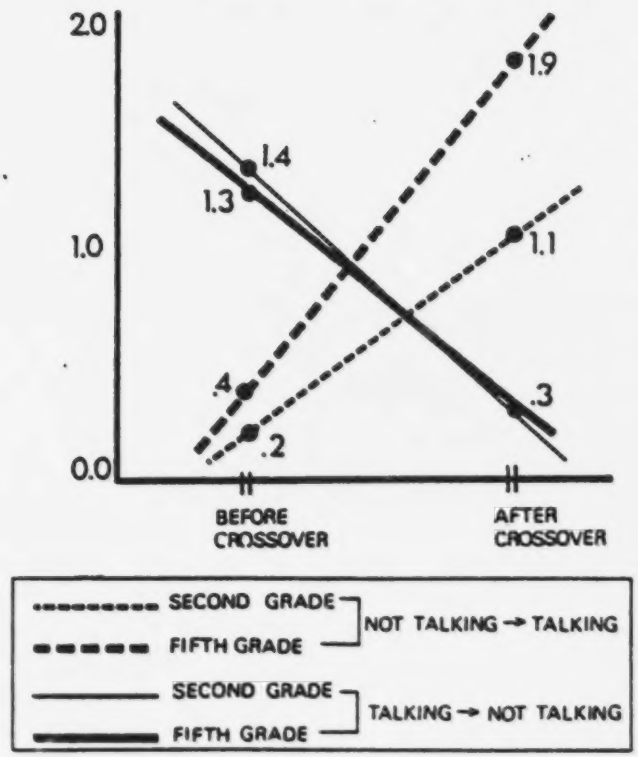

Figure 2: Story Level Editing:
Before and After Crossover